Net primary productivity of macrophyte communities in the experimental marshes after eleven growing seasons

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Introduction

Direct measurements of macrophyte net primary productivity (NPP) were first made at the experimental wetland basins of the Olentangy River Wetland Research Park (ORWRP) in 1997. This study in 2004 represents the eighth set of such measurements. Prior to 1997 (the fourth growing season), macrophyte harvesting for estimation of biomass was not considered a good option as vegetation was just getting established in the basins.

Methods

Aboveground net primary productivity (NPP) was estimated by harvesting peak biomass at the end of the growing season on August 9, 2004 at selected stations in the two experimental wetland basins at the ORWRP (Figure 1). The biomass harvesting stations that are used each year were established in 1997 along the permanent boardwalk system (Mitsch and Bouchard, 1998). To avoid harvesting plants from the exact same spots from one year to the next, 1-m^2 PVC sampling frames are tossed randomly from the boardwalks into the vegetation. These 1-m^2 frames are used to delineate quadrats in which vegetation is harvested. While there are potentially 22 stations in each wetland, a maximum of 16 sites are harvested annually in each basin, and stations lacking emergent vegetation are skipped. Fifteen quadrats were sampled in Wetland 1 and 10 quadrats were sampled in Wetland 2. Eight out of a possible eight plots were sampled in the northern half (inflow area) of Wetland 2, but only two out of a possible eight plots in the southern half of Wetland 2 were sampled. Vegetation in the outflow of Wetland 2 remains sparse since extensive herbivory occurred during 2002.

In each quadrat, plants were clipped at ground level (the water was lowered in the wetlands to facilitate sampling). Samples were segregated both by quadrat and by species, placed in plastic bags and weighed in the field with a hanging balance (accuracy ± 40 g). Sub-samples were taken to the laboratory where both wet weight and dry weight (dried at 105°F for 48 hours) were determined to estimate dry/wet ratios. Average ratios for each species were multiplied by the total wet weight of that species in each quadrat to estimate total dry weight production. The sum of all species in a quadrat was the estimated peak biomass, and hence annual aboveground net primary productivity (NPP).

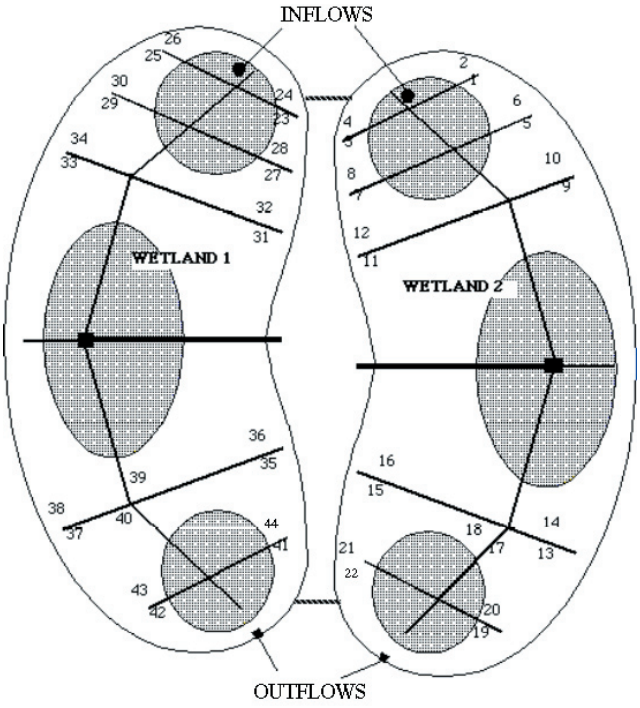

Figure 1. Potential sampling stations for macrophyte harvesting. Fifteen stations were sampled in Wetland 1 and 10 in Wetland 2 in 2004.

Results and Discussion

Comparison of Basins and Location

In 2004, macrophyte aboveground NPP was 408 ± 37 g $m^{-2} yr^{-1}$ for the 15 sites in Wetland 1, and 586 ± 91 g $m^{-2} yr^{-1}$ for the 10 sites in Wetland 2. Although productivity was similar at the inflow and outflow sites in the two wetlands (Figure 2), outflow results from Wetland 2 were based on only two sampling sites. Aside from the two areas in which biomass was harvested in the outflow of Wetland 2, this region had little emergent vegetation (see vegetation cover chapter).

Dry/Wet Ratios

As discussed in previous annual reports, dry/wet ratios of individual plant species that are necessary for estimating NPP are provided (Table 2).

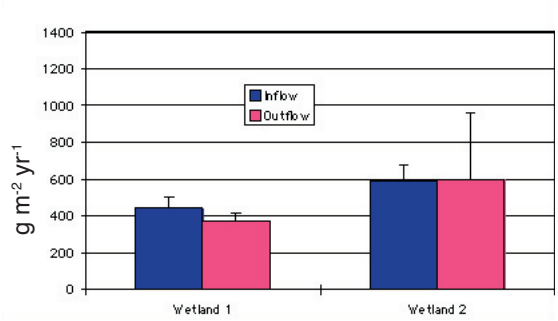

Figure 2. Aboveground net primary productivity in Wetland 1 and 2 inflow and outflow areas for 2004..

Table 1. Estimated net above-ground primary productivity (NPP) of macrophyte communities in the experimental wetlands based on peak biomass harvest, 1999 - 2004. Numbers are avg ± std error [# samples].

Wetland/ Year	Total NPP, g m^{-2} yr^{-1}	Inflow NPP, g m^{-2} yr^{-1}	Outflow NPP, g m^{-2} yr^{-1}
Wetland 1			
1999	657±76 [16]	601±126 [8]	714±90 [8]
2000	482±64 [16]	597±87 [8]	368±79 [8]
2001	393±87 [9]	454±98 [7]	181±120 [2]
2002	689±93 [16]	915±126 [8]	462±79 [8]
2003	432±60 [16]	570±90 [8]	295±45 [8]
2004	408±37 [15]	441±59 [8]	369±41 [7]
Wetland 2			
1999	1023±94 [16]	790±75 [8]	1256±130 [8]
2000	1013±105 [16]	882±126 [8]	1144±163 [8]
2001	832±85 [9]	746±76 [7]	1134±145 [2]
2002	519±64 [15]	699±84 [7]	361±53 [8]
2003	192±54 [10]	226±62 [8]	54±19 [2]
2004	586±91 [10]	583±92 [8]	596±361 [2]

Comparison with Previous Years

As a whole, macrophyte productivity in Wetland 1 in 2004 was similar to that of 2003, but productivity in Wetland 2 was higher in 2004 compared to 2003 (Figure 3). When paired sites were compared between the two wetlands in 2003 (16 sites), NPP on a plot-by-plot basis was not statistically different in (planted) Wetland 1 than in (naturally colonized) Wetland 2 ($\alpha = 0.05$). NPP, on a plot-by-plot basis, was significantly higher in in Wetland 2 compared to Wetland 1 for four years, from 1998 to 2001.

Species Dominating NPP

Macrophyte species found in sample quadrats in 2002 and 2003 are listed in Table 3. Data for 2002 are corrected from previously-published data (Mitsch et al., 2003). As was the case in previous years, the species harvested in the two wetlands indicate certain differences that can still be attributed to the original 1994 planting. Four of the 12 species planted in Wetland 1 (*Schoenoplectus tabernaemontani*, *Sparganium eurycarpum, Scirpus fluviatalis,* and *Sagittaria latifolia)* were still contributing to macrophyte productivity in both 2003 and 2004. *S. tabernaemontani* contributed 34% of the productivity in W1 and *Sparganium eurycarpum* added 26% of the productivity in 2004 (Table 3). The naturally colonizing species *Typha* and *Leersia* contributed 11 and 22% of the productivity in Wetland 1, respectively, in 2004.

Table 2. Dry/wet ratios (avg ± std error (# samples)) of dominant macrophyte species in the experimental wetlands from 2001-2004.

Species/	Wetland 1	Wetland 2
Schoenoplectus tabernaemontani		
2002	0.15±0.01 (14)	0.16±0.02 (14)
2003	0.16±0.01 (14)	0.05±0.01 (7)
2004	0.19±0.01 (14)	
Polygonum sp.		
2002	0.16±0.01 (13)	0.15±0.01 (7)
Scirpus fluviatilis		
2001	na	na
2002	0.13±0.03 (3)	na
2004	0.34±0.0 (2)	
Sagittaria latifolia		
2002	0.07±0.01 (3)	na
2004	0.22 (1)	
Sparganium eurycarpum		
2001	0.16±0.03 (7)	na
2002	0.10±0.01 (10)	na
2003	0.15±0.01 (15)	na
2004	0.17±0.01 (16)	na
Typha spp.		
2001	0.20±0.05 (2)	0.29±0.03 (9)
2002	0.14±0.03 (4)	0.21±0.04 (8)
2003	0.23±0.02 (5)	0.11±0.00 (3)
2004	0.21±0.02 (4)	
Leersia oryzoides		
2002	0.25±0.03 (10)	0.23 ± 0.02 (4)
2003	0.21±0.2 (15)	0.10±0.02 (6)
2004	0.27±0.03 (13)	
Cyperus sp.		
2002	0.15±0.01 (8)	0.21±0.02 (9)
Echinochloa sp.		
2002	0.13 ±0.03 (5)	0.17±0.04 (2)
Lycopus americanus		
2002	0.18±0.01 (2)	na
Ludwigia sp.		
2003	na	0.14±0.4 (2)
Alisma plantago		
2004	0.035 (1)	

S. tabernaemontani, which had reestablished from the seedbank in Wetland 2 during spring drawdown in 2001, accounted for 38% of the productivity of this wetland in 2004, and 37% of its productivity in 2003. *Typha* again dominated NPP in Wetland 2 with 57% of the productivity in 2004. By contrast, *Typha* contributed 41% of the productivity in Wetland 1 and 100% of the productivity in Wetland 2 in 2001, but lost dominance in both wetlands as a result of muskrat herbivory in winter 2001, followed by

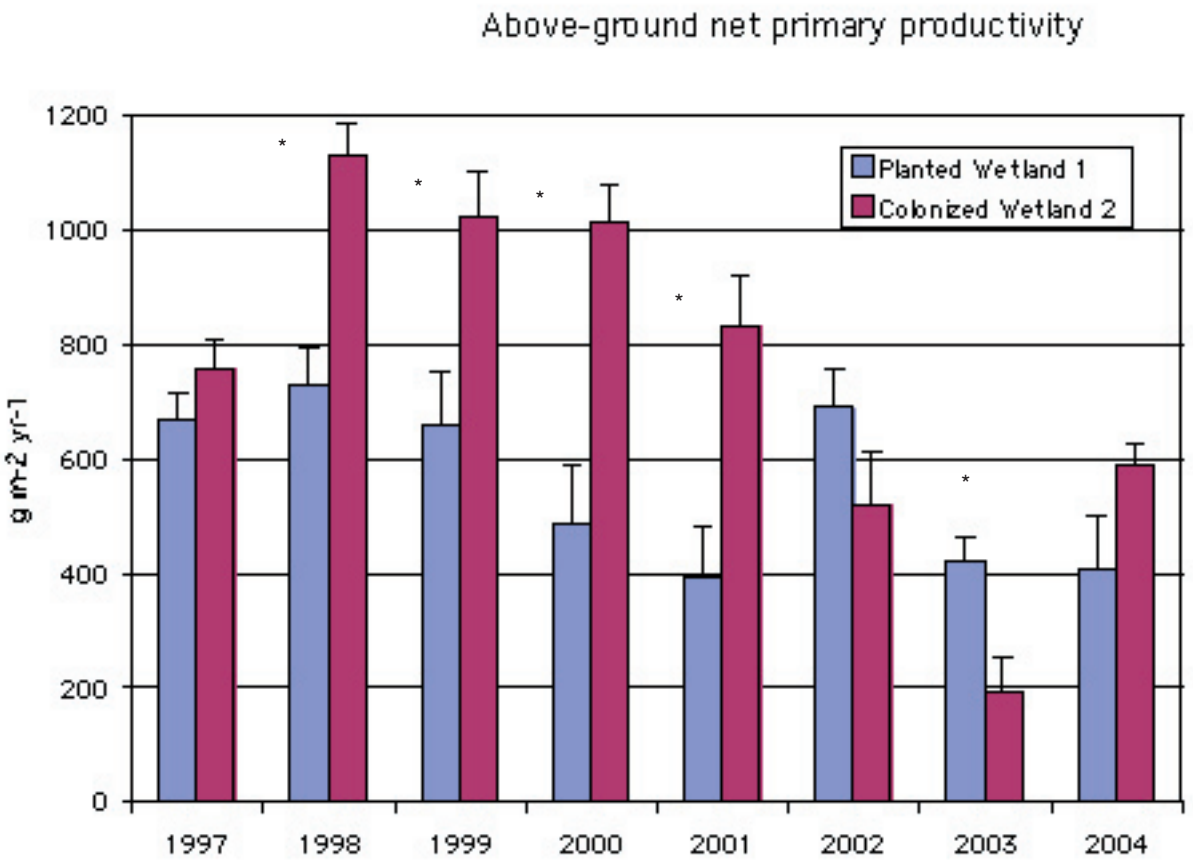

Figure 3. Aboveground net primary productivity for 1997-2004 in the experimental wetlands. * indicates significant differences between the two wetlands (α=0.05).

Table 3. Percent dominance of macrophytes according to aboveground primary productivity in quadrats in 2002 (n = 16 for W1; n = 15 for W2), 2003 (n = 16 for W1; n = 10 for W2) and 2004 (n = 15 for W1; n = 10 for W2), and species richness in quadrats. "nd" indicates not detected in biomass samples; 0.0 indicates species was present but did not contribute significantly to productivity.

	2002		2003		2004	
Species	W1	W2	W1	W2	W1	W2
Schoenoplectus t.,	72.8	55.9	36.7	37.3	33.8	38.1
Polygonum spp.	12.5	21.8	0.0	0.0	0.0	nd
Typha spp.	6.9	16.1	16.3	41.9	11.5	57.2
Sparganium eury.	0.5	nd	18.0	nd	26.4	nd
Leersia oryzoides	5.1	6.3	28.2	25.3	22.5	4.7
Cyperus sp.	1.9	5.7	0.0	nd	nd	nd
Echinochloa	0.6	0.4	0.0	nd	nd	nd
Panicum sp.	nd	0.2	nd	5.6	nd	nd
Lycopus sp.	0.5	0.0	nd	nd	nd	nd
Scirpus fluviatilis	0.5	nd	0.9	nd	5.3	nd
Sagittaria latifolia	0.4	0.0	0.0	nd	0.5	nd
Ludwigia palustris	0.0	0.0	nd	nd	nd	nd
Penthorum sedoides	nd	nd	nd	0.0	nd	nd
Gratiola virginiana	nd	nd	nd	0.0	nd	nd
Mimulus ringens	nd	nd	0.0	nd	nd	nd
Alisma plantago	nd	nd	nd	nd	0.0	nd
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
Species richness	11	10	10	7	8	3

seedbank regeneration and subsequent agressive growth by *Schoenoplectus* in 2002.

There were eight macrophyte species found in sampling plots in Wetland 1, and three species in Wetland 2, in 2004. By comparison, ten and seven species were found in 2003, and 11 and 10 species in 2002 in Wetlands 1 and 2 respectively. *Lycopus spp*. and *Ludwigia palustris* were seen in Wetland 1 in 2002, but not in 2003 or 2004, and *Mimulus ringens* was seen in sampling quadrats for the first time in 2003 in Wetland 1, but not in 2004. Smartweed *(Polygonum* spp.) continued to be found in both wetlands in 2003, although it did not contribute significantly to NPP. In 2004, *Polygonum* spp was found only in Wetland 1. This is a considerable decline from 2002, when it contributed 12 and 22% of the productivity respectively to Wetlands 1 and 2.

Table 4. Estimated macrophyte above-ground net primary productivity in each experimental wetland, 1997-2004 (kg dry-wt per wetland basin).

Year	Wetland 1	Wetland 2
2004	2,434	2,122
2003	2,397	625
2002	4,478	3,330
2001	963	1,250
2000	1,960	4,265
1999	5,800	6,800
1998	3,300	3,500
1997	2,525	3,040
Total	24,757	24,932

Basin Productivity

Based on the aboveground productivity estimates reported here, and on estimates of macrophyte cover presented elsewhere in this annual report (Mitsch et al., 2005; W1 = 5967 m^2; W2 = 3622 m^2), aboveground productivity of macrophytes was estimated to be 2434 and 2122 kg yr^{-1} in Wetlands 1 and 2 respectively (Table 4). Overall NPP increased slightly in Wetland 1, and increased three-fold in Wetland 2, from 2003 to 2004. The year 2004 is the third year in a row in which the planted Wetland 1 had a higher esimated macrophyte carbon sequestration than the naturally colonized Wetland 2. The cumulative organic matter production by macrophytes over the last eight-years is now almost equal in the two wetlands (~25 Mg $basin^{-1}$) (Table 4).

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